What is Claimed is:

1. A self-contained/interruption-free positioning system for a user on earth surface, comprising

a main inertial measurement unit (IMU) based self-contained/interruption-free positioning module is utilized for sensing motion measurements of said user and producing self-contained/interruption-free positioning data of said user;

a positioning assistant providing interruptible positioning data to assist said main IMU based self-contained/interruption-free positioning module to achieve improved self-contained/interruption-free positioning data of said user;

a wireless communication device for exchanging said improved self-contained/interruption-free positioning data with other users;

a map database providing map data to obtain a surrounding map information of location of said user by accessing said map database using said self-contained/interruption-free positioning data; and

a display device for visualizing said self-contained/interruption-free positioning data of said user using said surrounding map information.

2. The self-contained/interruption-free positioning system, as recited in claim 1, wherein said main IMU based self-contained/interruption-free positioning module comprises:

an inertial measurement unit (IMU) for sensing traveling displacement motions of said user so as to produce digital angular increments and velocity increments data in response to said traveling displacement motions of said user;

a north finder producing a heading measurement of said user;

a velocity producer producing velocity data in a body frame of said user; and

a navigation processor connected with said inertial measurement unit, said north finder, said velocity producer, and said positioning assistant, so as to receive said digital angular increments and velocity increments data, said heading measurement, said velocity data in said body frame, and the interruptible positioning data from said positioning assistant to produce IMU position, velocity, and attitude data, and an optimal estimate of errors of said IMU position, velocity, and attitude data for correcting said IMU position, velocity, and attitude data error to output corrected IMU position, velocity and attitude data.

3. The self-contained/interruption-free positioning system, as recited in claim 2, wherein said main IMU based self-contained/interruption-free positioning module further comprises an altitude measurement device for producing altitude measurement of said user to form a mean sea level height of said user.

4. The self-contained/interruption-free positioning system, as recited in claim 3, wherein said navigation processor utilizes an inertial navigation processing module for producing said IMU position, velocity, and attitude data, and an optimal filtering module for producing said optimal estimate of errors of said IMU position, velocity, and attitude data.

5. The self-contained/interruption-free positioning system, as recited in claim 4, wherein said navigation processor provides an integration Kalman filter to estimate and compensate INS errors and sensor errors.

6. The self-contained/interruption-free positioning system, as recited in claim 2, wherein said north finder is a magnetic sensor for sensing earth's magnetic field to measure said heading angle of said user.

7. The self-contained/interruption-free positioning system, as recited in claim 3, wherein said north finder is a magnetic sensor, including a flux valve and a

magnetometer, for sensing earth's magnetic field to measure said heading angle of said user.

8. The self-contained/interruption-free positioning system, as recited in claim 2, wherein said velocity producer provides relative velocity measurements of said user to a ground by sensing Doppler frequencies based on a Doppler effect.

9. The self-contained/interruption-free positioning system, as recited in claim 3, wherein said velocity producer provides relative velocity measurements of said user to a ground by sensing Doppler frequencies based on a Doppler effect.

10. The self-contained/interruption-free positioning system, as recited in claim 7, wherein said velocity producer provides relative velocity measurements of said user to a ground by sensing Doppler frequencies based on a Doppler effect.

11. The self-contained/interruption-free positioning system, as recited in claim 10, wherein said velocity producer is a radio frequency (RF) velocity producer which includes a radar.

12. The self-contained/interruption-free positioning system, as recited in claim 10, wherein said velocity producer is an acoustic velocity producer which includes a sensor.

13. The self-contained/interruption-free positioning system, as recited in claim 10, wherein said velocity producer is a laser velocity producer which includes a laser radar.

14. The self-contained/interruption-free positioning system, as recited in claim 1, wherein said positioning assistant includes a GPS receiver connected with said navigation processor to receive GPS RF (radio frequency) signals to produce GPS positioning data to said navigation processor in order to further improve accuracy of said self-contained/interruption-free positioning data when said GPS signals are available.

15. The self-contained/interruption-free positioning system, as recited in claim 2, wherein said positioning assistant includes a GPS receiver connected with said navigation processor to receive GPS RF (radio frequency) signals to produce GPS positioning data to said navigation processor in order to further improve accuracy of said self-contained/interruption-free positioning data when said GPS signals are available.

16. The self-contained/interruption-free positioning system, as recited in claim 3, wherein said positioning assistant includes a GPS receiver connected with said navigation processor to receive GPS RF (radio frequency) signals to produce GPS positioning data to said navigation processor in order to further improve accuracy of said self-contained/interruption-free positioning data when said GPS signals are available.

17. The self-contained/interruption-free positioning system, as recited in claim 6, wherein said positioning assistant includes a GPS receiver connected with said navigation processor to receive GPS RF (radio frequency) signals to produce GPS positioning data to said navigation processor in order to further improve accuracy of said self-contained/interruption-free positioning data when said GPS signals are available.

18. The self-contained/interruption-free positioning system, as recited in claim 8, wherein said positioning assistant includes a GPS receiver connected with said navigation processor to receive GPS RF (radio frequency) signals to produce GPS positioning data to said navigation processor in order to further improve accuracy of said self-contained/interruption-free positioning data when said GPS signals are available.

19. The self-contained/interruption-free positioning system, as recited in claim 10, wherein said positioning assistant includes a GPS receiver connected with said navigation processor to receive GPS RF (radio frequency) signals to produce GPS positioning data to said navigation processor in order to further improve accuracy of said self-contained/interruption-free positioning data when said GPS signals are available.

20. The self-contained/interruption-free positioning system, as recited in claim 14 or 15, wherein said positioning assistant further includes a data link for receiving said GPS positioning data from a GPS reference site to perform differential GPS positioning.

21. The self-contained/interruption-free positioning system, as recited in claim 1, wherein said positioning assistant is a radio positioning system based on said wireless communication device.

22. The self-contained/interruption-free positioning system, as recited in claim 2, wherein said positioning assistant is a radio positioning system based on said wireless communication device.

23. The self-contained/interruption-free positioning system, as recited in claim 3, wherein said positioning assistant is a radio positioning system based on said wireless communication device.

24. The self-contained/interruption-free positioning system, as recited in claim 6, wherein said positioning assistant is a radio positioning system based on said wireless communication device.

25. The self-contained/interruption-free positioning system, as recited in claim 8, wherein said positioning assistant is a radio positioning system based on said wireless communication device.

26. The self-contained/interruption-free positioning system, as recited in claim 10, wherein said positioning assistant is a radio positioning system based on said wireless communication device.

27. The self-contained/interruption-free positioning system, as recited in claim 3, wherein said navigation processor further provides:

an INS computation module, using said digital angular increments and velocity increments signals from said inertial measurement unit to produce inertial positioning measurement;

an integration Kalman filter for estimating errors of said inertial positioning measurements to calibrate inertial positioning errors;

a magnetic sensor processing module for producing a heading angle;

a velocity producer processing module for producing relative position error measurements for said integration Kalman filter; and

an altitude measurement processing module for forming said mean sea level height in said digital data type using said altitude measurement.

28. The self-contained/interruption-free positioning system, as recited in claim 27, wherein said INS computation module further comprises:

a sensor compensation module for calibrating errors of said digital angular increments and velocity increments signals: and

an inertial navigation algorithm module for computing IMU position, velocity and attitude data.

29. The self-contained/interruption-free positioning system, as recited in claim 28, wherein said inertial integration algorithm module comprises:

an attitude integration module for integrating said angular increments into said attitude data;

a velocity integration module for transforming said measured velocity increments into a navigation coordinate frame by using said attitude data to form transformed velocity increments which are integrated into said velocity data; and

a position integration module for integrating said navigation frame velocity data into said position data.

30. The self-contained/interruption-free positioning system, as recited in claim 29, wherein said velocity producer processing module further comprises:

a transformation module for transforming an input velocity data expressed in said body frame to a velocity expressed in a navigation frame;

a scale factor and misalignment error compensation module for compensating scale factor and misalignment errors in said velocity; and

a relative position computation for receiving said IMU velocity and attitude data and compensated velocity to form said relative position error measurements for said integration Kalman filter.

31. The self-contained/interruption-free positioning system, as recited in claim 30, wherein said integration Kalman filter comprises:

a motion test module for determining if said user stops automatically;

a GPS integrity monitor for determining if said GPS data is available;

a measurement and time varying matrix formation module for formulating said measurement and time varying matrix for said state estimation module according to a motion status of said user from said motion test module and GPS data availability from said GPS integrity monitor; and

a state estimation module for filtering said measurements and obtaining said optimal estimates of said IMU positioning errors.

32. The self-contained/interruption-free positioning system, as recited in claim 31, wherein said state estimation module provides a horizontal filter for obtaining said estimates of said horizontal IMU positioning errors, and a vertical filter for obtaining said estimates of vertical IMU positioning errors.

33. The self-contained/interruption-free positioning system, as recited in claim 32, wherein said motion test module provides:

a velocity producer change test module for receiving said velocity producer reading to determining if said user stops or restarts;

a system velocity change test module for comparing system velocity change between said current interval and said previous interval to determine if said user stops or restarts;

a system velocity test module for comparing said system velocity magnitude with a predetermined value to determine whether said user stops or restarts; and

an attitude change test module for comparing said system attitude magnitude with a predetermined value to determine whether said user stops or restarts.

34. The self-contained/interruption-free positioning system, as recited in claim 7, wherein said navigation processor further provides:

an INS computation module, using said digital angular increments and velocity increments signals from said inertial measurement unit to produce inertial positioning measurement;

an integration Kalman filter for estimating errors of said inertial positioning measurements to calibrate inertial positioning errors;

a magnetic sensor processing module for producing a heading angle;

a velocity producer processing module for producing relative position error measurements for said integration Kalman filter; and

an altitude measurement processing module for forming said mean sea level height in said digital data type using said altitude measurement.

35. The self-contained/interruption-free positioning system, as recited in claim 34, wherein said INS computation module further comprises:

a sensor compensation module for calibrating errors of said digital angular increments and velocity increments signals: and

an inertial navigation algorithm module for computing IMU position, velocity and attitude data.

36. The self-contained/interruption-free positioning system, as recited in claim 35, wherein said inertial integration algorithm module comprises:

an attitude integration module for integrating said angular increments into said attitude data;

a velocity integration module for transforming said measured velocity increments into a navigation coordinate frame by using said attitude data to form transformed velocity increments which are integrated into said velocity data; and

a position integration module for integrating said navigation frame velocity data into said position data.

37. The self-contained/interruption-free positioning system, as recited in claim 36, wherein said velocity producer processing module further comprises:

a transformation module for transforming an input velocity data expressed in said body frame to a velocity expressed in a navigation frame;

a scale factor and misalignment error compensation module for compensating scale factor and misalignment errors in said velocity; and

a relative position computation for receiving said IMU velocity and attitude data and compensated velocity to form said relative position error measurements for said integration Kalman filter.

38. The self-contained/interruption-free positioning system, as recited in claim 37, wherein said integration Kalman filter comprises:

a motion test module for determining if said user stops automatically;

a GPS integrity monitor for determining if said GPS data is available;

a measurement and time varying matrix formation module for formulating said measurement and time varying matrix for said state estimation module according to a motion status of said user from said motion test module and GPS data availability from said GPS integrity monitor; and

a state estimation module for filtering said measurements and obtaining said optimal estimates of said IMU positioning errors.

39. The self-contained/interruption-free positioning system, as recited in claim 38, wherein said state estimation module provides a horizontal filter for obtaining said estimates of said horizontal IMU positioning errors, and a vertical filter for obtaining said estimates of vertical IMU positioning errors.

40. The self-contained/interruption-free positioning system, as recited in claim 39, wherein said motion test module provides:

a velocity producer change test module for receiving said velocity producer reading to determining if said user stops or restarts;

a system velocity change test module for comparing system velocity change between said current interval and said previous interval to determine if said user stops or restarts;

a system velocity test module for comparing said system velocity magnitude with a predetermined value to determine whether said user stops or restarts; and

an attitude change test module for comparing said system attitude magnitude with a predetermined value to determine whether said user stops or restarts.

41. The self-contained/interruption-free positioning system, as recited in of claim 10, wherein said navigation processor further provides:

an INS computation module, using said digital angular increments and velocity increments signals from said inertial measurement unit to produce inertial positioning measurement;

an integration Kalman filter for estimating errors of said inertial positioning measurements to calibrate inertial positioning errors;

a magnetic sensor processing module for producing a heading angle;

a velocity producer processing module for producing relative position error measurements for said integration Kalman filter; and

an altitude measurement processing module for forming said mean sea level height in said digital data type using said altitude measurement.

42. The self-contained/interruption-free positioning system, as recited in claim 41, wherein said INS computation module further comprises:

a sensor compensation module for calibrating errors of said digital angular increments and velocity increments signals: and

an inertial navigation algorithm module for computing IMU position, velocity and attitude data.

43. The self-contained/interruption-free positioning system, as recited in claim 42, wherein said inertial integration algorithm module comprises:

an attitude integration module for integrating said angular increments into said attitude data;

a velocity integration module for transforming said measured velocity increments into a navigation coordinate frame by using said attitude data to form transformed velocity increments which are integrated into said velocity data; and

a position integration module for integrating said navigation frame velocity data into said position data.

44. The self-contained/interruption-free positioning system, as recited in claim 43, wherein said velocity producer processing module further comprises:

a transformation module for transforming an input velocity data expressed in said body frame to a velocity expressed in a navigation frame;

a scale factor and misalignment error compensation module for compensating scale factor and misalignment errors in said velocity; and

a relative position computation for receiving said IMU velocity and attitude data and compensated velocity to form said relative position error measurements for said integration Kalman filter.

45. The self-contained/interruption-free positioning system, as recited in claim 44, wherein said integration Kalman filter comprises:

a motion test module for determining if said user stops automatically;

a GPS integrity monitor for determining if said GPS data is available;

a measurement and time varying matrix formation module for formulating said measurement and time varying matrix for said state estimation module according to a motion status of said user from said motion test module and GPS data availability from said GPS integrity monitor; and

a state estimation module for filtering said measurements and obtaining said optimal estimates of said IMU positioning errors.

46. The self-contained/interruption-free positioning system, as recited in claim 45, wherein said state estimation module provides a horizontal filter for obtaining said estimates of said horizontal IMU positioning errors, and a vertical filter for obtaining said estimates of vertical IMU positioning errors.

47. The self-contained/interruption-free positioning system, as recited in claim 46, wherein said motion test module provides:

a velocity producer change test module for receiving said velocity producer reading to determining if said user stops or restarts;

a system velocity change test module for comparing system velocity change between said current interval and said previous interval to determine if said user stops or restarts;

a system velocity test module for comparing said system velocity magnitude with a predetermined value to determine whether said user stops or restarts; and

an attitude change test module for comparing said system attitude magnitude with a predetermined value to determine whether said user stops or restarts.

48. The self-contained/interruption-free positioning system, as recited in of claim 16, wherein said navigation processor further provides:

an INS computation module, using said digital angular increments and velocity increments signals from said inertial measurement unit to produce inertial positioning measurement;

an integration Kalman filter for estimating errors of said inertial positioning measurements to calibrate inertial positioning errors;

a magnetic sensor processing module for producing a heading angle;

a velocity producer processing module for producing relative position error measurements for said integration Kalman filter; and

an altitude measurement processing module for forming said mean sea level height in said digital data type using said altitude measurement.

49. The self-contained/interruption-free positioning system, as recited in claim 48, wherein said INS computation module further comprises:

a sensor compensation module for calibrating errors of said digital angular increments and velocity increments signals: and

an inertial navigation algorithm module for computing IMU position, velocity and attitude data.

50. The self-contained/interruption-free positioning system, as recited in claim 49, wherein said inertial integration algorithm module comprises:

an attitude integration module for integrating said angular increments into said attitude data;

a velocity integration module for transforming said measured velocity increments into a navigation coordinate frame by using said attitude data to form transformed velocity increments which are integrated into said velocity data; and

a position integration module for integrating said navigation frame velocity data into said position data.

51. The self-contained/interruption-free positioning system, as recited in claim 50, wherein said velocity producer processing module further comprises:

a transformation module for transforming an input velocity data expressed in said body frame to a velocity expressed in a navigation frame;

a scale factor and misalignment error compensation module for compensating scale factor and misalignment errors in said velocity; and

a relative position computation for receiving said IMU velocity and attitude data and compensated velocity to form said relative position error measurements for said integration Kalman filter.

52. The self-contained/interruption-free positioning system, as recited in claim 51, wherein said integration Kalman filter comprises:

a motion test module for determining if said user stops automatically;

a GPS integrity monitor for determining if said GPS data is available;

a measurement and time varying matrix formation module for formulating said measurement and time varying matrix for said state estimation module according to a motion status of said user from said motion test module and GPS data availability from said GPS integrity monitor; and

a state estimation module for filtering said measurements and obtaining said optimal estimates of said IMU positioning errors.

53. The self-contained/interruption-free positioning system, as recited in claim 52, wherein said state estimation module provides a horizontal filter for obtaining said estimates of said horizontal IMU positioning errors, and a vertical filter for obtaining said estimates of vertical IMU positioning errors.

54. The self-contained/interruption-free positioning system, as recited in claim 53, wherein said motion test module provides:

a velocity producer change test module for receiving said velocity producer reading to determining if said user stops or restarts;

a system velocity change test module for comparing system velocity change between said current interval and said previous interval to determine if said user stops or restarts;

a system velocity test module for comparing said system velocity magnitude with a predetermined value to determine whether said user stops or restarts; and

an attitude change test module for comparing said system attitude magnitude with a predetermined value to determine whether said user stops or restarts.

55. The self-contained/interruption-free positioning system, as recited in of claim 19, wherein said navigation processor further provides:

an INS computation module, using said digital angular increments and velocity increments signals from said inertial measurement unit to produce inertial positioning measurement;

an integration Kalman filter for estimating errors of said inertial positioning measurements to calibrate inertial positioning errors;

a magnetic sensor processing module for producing a heading angle;

a velocity producer processing module for producing relative position error measurements for said integration Kalman filter; and

an altitude measurement processing module for forming said mean sea level height in said digital data type using said altitude measurement.

56. The self-contained/interruption-free positioning system, as recited in claim 55, wherein said INS computation module further comprises:

a sensor compensation module for calibrating errors of said digital angular increments and velocity increments signals: and

an inertial navigation algorithm module for computing IMU position, velocity and attitude data.

57. The self-contained/interruption-free positioning system, as recited in claim 56, wherein said inertial integration algorithm module comprises:

an attitude integration module for integrating said angular increments into said attitude data;

a velocity integration module for transforming said measured velocity increments into a navigation coordinate frame by using said attitude data to form transformed velocity increments which are integrated into said velocity data; and

a position integration module for integrating said navigation frame velocity data into said position data.

58. The self-contained/interruption-free positioning system, as recited in claim 57, wherein said velocity producer processing module further comprises:

a transformation module for transforming an input velocity data expressed in said body frame to a velocity expressed in a navigation frame;

a scale factor and misalignment error compensation module for compensating scale factor and misalignment errors in said velocity; and

a relative position computation for receiving said IMU velocity and attitude data and compensated velocity to form said relative position error measurements for said integration Kalman filter.

59. The self-contained/interruption-free positioning system, as recited in claim 58, wherein said integration Kalman filter comprises:

a motion test module for determining if said user stops automatically;

a GPS integrity monitor for determining if said GPS data is available;

a measurement and time varying matrix formation module for formulating said measurement and time varying matrix for said state estimation module according to a

motion status of said user from said motion test module and GPS data availability from said GPS integrity monitor; and

a state estimation module for filtering said measurements and obtaining said optimal estimates of said IMU positioning errors.

60. The self-contained/interruption-free positioning system, as recited in claim 59, wherein said state estimation module provides a horizontal filter for obtaining said estimates of said horizontal IMU positioning errors, and a vertical filter for obtaining said estimates of vertical IMU positioning errors.

61. The self-contained/interruption-free positioning system, as recited in claim 60, wherein said motion test module provides:

a velocity producer change test module for receiving said velocity producer reading to determining if said user stops or restarts;

a system velocity change test module for comparing system velocity change between said current interval and said previous interval to determine if said user stops or restarts;

a system velocity test module for comparing said system velocity magnitude with a predetermined value to determine whether said user stops or restarts; and

an attitude change test module for comparing said system attitude magnitude with a predetermined value to determine whether said user stops or restarts.

62. The self-contained/interruption-free positioning system, as recited in of claim 23, wherein said navigation processor further provides:

an INS computation module, using said digital angular increments and velocity increments signals from said inertial measurement unit to produce inertial positioning measurement;

an integration Kalman filter for estimating errors of said inertial positioning measurements to calibrate inertial positioning errors;

a magnetic sensor processing module for producing a heading angle;

a velocity producer processing module for producing relative position error measurements for said integration Kalman filter; and

an altitude measurement processing module for forming said mean sea level height in said digital data type using said altitude measurement.

63. The self-contained/interruption-free positioning system, as recited in claim 62, wherein said INS computation module further comprises:

a sensor compensation module for calibrating errors of said digital angular increments and velocity increments signals: and

an inertial navigation algorithm module for computing IMU position, velocity and attitude data.

64. The self-contained/interruption-free positioning system, as recited in claim 63, wherein said inertial integration algorithm module comprises:

an attitude integration module for integrating said angular increments into said attitude data;

a velocity integration module for transforming said measured velocity increments into a navigation coordinate frame by using said attitude data to form transformed velocity increments which are integrated into said velocity data; and

a position integration module for integrating said navigation frame velocity data into said position data.

65. The self-contained/interruption-free positioning system, as recited in claim 64, wherein said velocity producer processing module further comprises:

a transformation module for transforming an input velocity data expressed in said body frame to a velocity expressed in a navigation frame;

a scale factor and misalignment error compensation module for compensating scale factor and misalignment errors in said velocity; and

a relative position computation for receiving said IMU velocity and attitude data and compensated velocity to form said relative position error measurements for said integration Kalman filter.

66. The self-contained/interruption-free positioning system, as recited in claim 65, wherein said integration Kalman filter comprises:

a motion test module for determining if said user stops automatically;

a GPS integrity monitor for determining if said GPS data is available;

a measurement and time varying matrix formation module for formulating said measurement and time varying matrix for said state estimation module according to a motion status of said user from said motion test module and GPS data availability from said GPS integrity monitor; and

a state estimation module for filtering said measurements and obtaining said optimal estimates of said IMU positioning errors.

67. The self-contained/interruption-free positioning system, as recited in claim 66, wherein said state estimation module provides a horizontal filter for obtaining said estimates of said horizontal IMU positioning errors, and a vertical filter for obtaining said estimates of vertical IMU positioning errors.

68. The self-contained/interruption-free positioning system, as recited in claim 67, wherein said motion test module provides:

a velocity producer change test module for receiving said velocity producer reading to determining if said user stops or restarts;

a system velocity change test module for comparing system velocity change between said current interval and said previous interval to determine if said user stops or restarts;

a system velocity test module for comparing said system velocity magnitude with a predetermined value to determine whether said user stops or restarts; and

an attitude change test module for comparing said system attitude magnitude with a predetermined value to determine whether said user stops or restarts.

69. The self-contained/interruption-free positioning system, as recited in of claim 26, wherein said navigation processor further provides:

an INS computation module, using said digital angular increments and velocity increments signals from said inertial measurement unit to produce inertial positioning measurement;

an integration Kalman filter for estimating errors of said inertial positioning measurements to calibrate inertial positioning errors;

a magnetic sensor processing module for producing a heading angle;

a velocity producer processing module for producing relative position error measurements for said integration Kalman filter; and

an altitude measurement processing module for forming said mean sea level height in said digital data type using said altitude measurement.

70. The self-contained/interruption-free positioning system, as recited in claim 69, wherein said INS computation module further comprises:

a sensor compensation module for calibrating errors of said digital angular increments and velocity increments signals: and

an inertial navigation algorithm module for computing IMU position, velocity and attitude data.

71. The self-contained/interruption-free positioning system, as recited in claim 70, wherein said inertial integration algorithm module comprises:

an attitude integration module for integrating said angular increments into said attitude data;

a velocity integration module for transforming said measured velocity increments into a navigation coordinate frame by using said attitude data to form transformed velocity increments which are integrated into said velocity data; and

a position integration module for integrating said navigation frame velocity data into said position data.

72. The self-contained/interruption-free positioning system, as recited in claim 71, wherein said velocity producer processing module further comprises:

a transformation module for transforming an input velocity data expressed in said body frame to a velocity expressed in a navigation frame;

a scale factor and misalignment error compensation module for compensating scale factor and misalignment errors in said velocity; and

a relative position computation for receiving said IMU velocity and attitude data and compensated velocity to form said relative position error measurements for said integration Kalman filter.

73. The self-contained/interruption-free positioning system, as recited in claim 72, wherein said integration Kalman filter comprises:

a motion test module for determining if said user stops automatically;

a GPS integrity monitor for determining if said GPS data is available;

a measurement and time varying matrix formation module for formulating said measurement and time varying matrix for said state estimation module according to a motion status of said user from said motion test module and GPS data availability from said GPS integrity monitor; and

a state estimation module for filtering said measurements and obtaining said optimal estimates of said IMU positioning errors.

74. The self-contained/interruption-free positioning system, as recited in claim 73, wherein said state estimation module provides a horizontal filter for obtaining said estimates of said horizontal IMU positioning errors, and a vertical filter for obtaining said estimates of vertical IMU positioning errors.

75. The self-contained/interruption-free positioning system, as recited in claim 74, wherein said motion test module provides:

a velocity producer change test module for receiving said velocity producer reading to determining if said user stops or restarts;

a system velocity change test module for comparing system velocity change between said current interval and said previous interval to determine if said user stops or restarts;

a system velocity test module for comparing said system velocity magnitude with a predetermined value to determine whether said user stops or restarts; and

an attitude change test module for comparing said system attitude magnitude with a predetermined value to determine whether said user stops or restarts.

76. The self-contained/interruption-free positioning system, as recited in claim 3 or 75, wherein said inertial measurement unit is a coremicro inertial measurement unit which comprises:

an angular rate producer for producing X axis, Y axis and Z axis angular rate electrical signals;

an acceleration producer for producing X axis, Y axis and Z axis acceleration electrical signals; and

an angular increment and velocity increment producer for converting said X axis, Y axis and Z axis angular rate electrical signals into digital angular increments and converting said input X axis, Y axis and Z axis acceleration electrical signals into digital velocity increments.

77. The self-contained/interruption-free positioning system, as recited in claim 76, wherein said coremicro inertial measurement unit further comprises a thermal controlling means for maintaining a predetermined operating temperature of said angular rate producer, said acceleration producer and said angular increment and velocity increment producer.

78. The self-contained/interruption-free positioning system, as recited in claim 77, wherein said thermal controlling means comprises a thermal sensing producer device, a heater device and a thermal processor, wherein said thermal sensing producer device, which produces temperature signals, is processed in parallel with said angular rate producer and said acceleration producer for maintaining a predetermined operating temperature of said angular rate producer and said acceleration producer and angular increment and velocity increment producer, wherein said predetermined operating temperature is a constant designated temperature selected between 150°F and 185°F, wherein said temperature signals produced from said thermal sensing producer device are input to said thermal processor for computing temperature control commands using said temperature signals, a temperature scale factor, and a predetermined operating temperature of said angular rate producer and said acceleration producer, and produce driving signals to said heater device using said temperature control commands for controlling said heater device to provide adequate heat for maintaining said predetermined operating temperature in said coremicro inertial measurement unit.

79. The self-contained/interruption-free positioning system, as recited in claim 78, wherein said X axis, Y axis and Z axis angular rate electrical signals produced from said angular producer are analog angular rate voltage signals directly proportional to angular rates of a carrier carrying said coremicro inertial measurement unit, and said X axis, Y axis and Z axis acceleration electrical signals produced from said acceleration producer are analog acceleration voltage signals directly proportional to accelerations of said vehicle.

80. The self-contained/interruption-free positioning system, as recited in claim 79, wherein said angular increment and velocity increment producer comprises:

an angular integrating means and an acceleration integrating means, which are adapted for respectively integrating said X axis, Y axis and Z axis analog angular rate voltage signals and said X axis, Y axis and Z axis analog acceleration voltage signals for a predetermined time interval to accumulate said X axis, Y axis and Z axis analog angular rate voltage signals and said X axis, Y axis and Z axis analog acceleration voltage signals as a raw X axis, Y axis and Z axis angular increment and a raw X axis, Y axis and Z axis velocity increment for a predetermined time interval to achieve accumulated angular increments and accumulated velocity increments, wherein said integration is performed to remove noise signals that are non-directly proportional to said carrier angular rate and acceleration within said X axis, Y axis and Z axis analog angular rate voltage signals and said X axis, Y axis and Z axis analog acceleration voltage signals, to improve signal-to-noise ratio, and to remove said high frequency signals in said X axis, Y axis and Z axis analog angular rate voltage signals and said X axis, Y axis and Z axis analog acceleration voltage signals;

a resetting means which forms an angular reset voltage pulse and a velocity reset voltage pulse as an angular scale and a velocity scale which are input into said angular integrating means and said acceleration integrating means respectively; and

an angular increment and velocity increment measurement means which is adapted for measuring said voltage values of said X axis, Y axis and Z axis accumulated angular increments and said X axis, Y axis and Z axis accumulated velocity increments with said angular reset voltage pulse and said velocity reset voltage pulse respectively to acquire angular increment counts and velocity increment counts as a digital form of angular increment and velocity increment measurements respectively.

81. The self-contained/interruption-free positioning system, as recited in claim 80, wherein said angular increment and velocity increment measurement means also scales said voltage values of said X axis, Y axis and Z axis accumulated angular and

velocity increments into real X axis, Y axis and Z axis angular and velocity increment voltage values, wherein in said angular integrating means and said accelerating integrating means, said X axis, Y axis and Z axis analog angular voltage signals and said X axis, Y axis and Z axis analog acceleration voltage signals are each reset to accumulate from a zero value at an initial point of every said predetermined time interval.

82. The self-contained/interruption-free positioning system, as recited in claim 81, wherein said resetting means comprises an oscillator, wherein said angular reset voltage pulse and said velocity reset voltage pulse are implemented by producing a timing pulse by said oscillator.

83. The self-contained/interruption-free positioning system, as recited in claim 82, wherein said angular increment and velocity increment measurement means, which is adapted for measuring said voltage values of said X axis, Y axis and Z axis accumulated angular and velocity increments, comprises an analog/digital converter to substantially digitize said raw X axis, Y axis and Z axis angular increment and velocity increment voltage values into digital X axis, Y axis and Z axis angular increment and velocity increments.

84. The self-contained/interruption-free positioning system, as recited in claim 83, wherein said angular integrating means of said angular increment and velocity increment producer comprises an angular integrator circuit for receiving said amplified X axis, Y axis and Z axis analog angular rate signals from said angular amplifier circuit and integrating to form said accumulated angular increments, and said acceleration integrating means of said angular increment and velocity increment producer comprises an acceleration integrator circuit for receiving said amplified X axis, Y axis and Z axis analog acceleration signals from said acceleration amplifier circuit and integrating to form said accumulated velocity increments.

85. The self-contained/interruption-free positioning system, as recited in claim 84, wherein said angular increment and velocity increment producer further comprises an angular amplifying circuit for amplifying said X axis, Y axis and Z axis analog angular

rate voltage signals to form amplified X axis, Y axis and Z axis analog angular rate signals and an acceleration amplifying circuit for amplifying said X axis, Y axis and Z axis analog acceleration voltage signals to form amplified X axis, Y axis and Z axis analog acceleration signals.

86. The self-contained/interruption-free positioning system, as recited in claim 85, wherein said angular integrating means of said angular increment and velocity increment producer comprises an angular integrator circuit for receiving said amplified X axis, Y axis and Z axis analog angular rate signals from said angular amplifier circuit and integrating to form said accumulated angular increments, and said acceleration integrating means of said angular increment and velocity increment producer comprises an acceleration integrator circuit for receiving said amplified X axis, Y axis and Z axis analog acceleration signals from said acceleration amplifier circuit and integrating to form said accumulated velocity increments.

87. The self-contained/interruption-free positioning system, as recited in claim 86, wherein said analog/digital converter of said angular increment and velocity increment producer further includes an angular analog/digital converter, a velocity analog/digital converter and an input/output interface circuit, wherein said accumulated angular increments output from said angular integrator circuit and said accumulated velocity increments output from said acceleration integrator circuit are input into said angular analog/digital converter and said velocity analog/digital converter respectively, wherein said accumulated angular increments is digitized by said angular analog/digital converter by measuring said accumulated angular increments with said angular reset voltage pulse to form a digital angular measurements of voltage in terms of said angular increment counts which is output to said input/output interface circuit to generate digital X axis, Y axis and Z axis angular increment voltage values, wherein said accumulated velocity increments are digitized by said velocity analog/digital converter by measuring said accumulated velocity increments with said velocity reset voltage pulse to form digital velocity measurements of voltage in terms of said velocity increment counts which

is output to said input/output interface circuit to generate digital X axis, Y axis and Z axis velocity increment voltage values.

88. The self-contained/interruption-free positioning system, as recited in claim 87, wherein said thermal processor comprises an analog/digital converter connected to said thermal sensing producer device, a digital/analog converter connected to said heater device, and a temperature controller connected with both said analog/digital converter and said digital/analog converter, wherein said analog/digital converter inputs said temperature voltage signals produced by said thermal sensing producer device, wherein said temperature voltage signals are sampled in said analog/digital converter to sampled temperature voltage signals which are further digitized to digital signals and output to said temperature controller which computes digital temperature commands using said input digital signals from said analog/digital converter, a temperature sensor scale factor, and a pre-determined operating temperature of said angular rate producer and acceleration producer, wherein said digital temperature commands are fed back to said digital/analog converter, wherein said digital/analog converter converts said digital temperature commands input from said temperature controller into analog signals which are output to said heater device to provide adequate heat for maintaining said predetermined operating temperature of said coremicro inertial measurement unit.

89. The self-contained/interruption-free positioning system, as recited in claim 88, wherein said thermal processor further comprises:

a first amplifier circuit between said thermal sensing producer device and said digital/analog converter, wherein said voltage signals from said thermal sensing producer device is first input into said first amplifier circuit for amplifying said signals and suppressing said noise residing in said voltage signals and improving said signal-to-noise ratio, wherein said amplified voltage signals are then output to said analog/digital converter; and

a second amplifier circuit between said digital/analog converter and heater device for amplifying said input analog signals from said digital/analog converter for driving said heater device.

90. The self-contained/interruption-free positioning system, as recited in claim 89, wherein said thermal processor further comprises an input/output interface circuit connected said analog/digital converter and digital/analog converter with said temperature controller, wherein said voltage signals are sampled in said analog/digital converter to form sampled voltage signals that are digitized into digital signals, and said digital signals are output to said input/output interface circuit, wherein said temperature controller is adapted to compute said digital temperature commands using said input digital temperature voltage signals from said input/output interface circuit, said temperature sensor scale factor, and said pre-determined operating temperature of said angular rate producer and acceleration producer, wherein said digital temperature commands are fed back to said input/output interface circuit, moreover said digital/analog converter further converts said digital temperature commands input from said input/output interface circuit into analog signals which are output to said heater device to provide adequate heat for maintaining said predetermined operating temperature of said coremicro inertial measurement unit.

91. A self-contained/interruption-free positioning method for a user on earth surface, comprising the steps of:

(a) sensing motion measurements of said user by a main IMU (Inertial Measurement Unit) to produce digital angular increments and velocity increments signals in response to a user motion,

(b) providing interruptible positioning data to assist said main IMU based self-contained/interruption-free positioning module by a positioning assistant,

(c) producing self-contained/interruption-free positioning data of said user using motion measurements, and improving self-contained/interruption-free positioning

data of said user to form improved self-contained/interruption-free positioning data when said interruptible positioning data is available,

(d) exchanging said improved self-contained/interruption-free positioning data with other users by a wireless communication device,

(e) providing map data to obtain a surrounding map information of location of said user by accessing a map database using said improved self-contained/interruption-free positioning data, and

(f) visualizing said improved self-contained/interruption-free positioning data of said user using said surrounding map information by a display device.

92. The self-contained/interruption-free positioning method, as recited in claim 91, wherein the step (b) further comprises a step of deducing GPS positioning data produced from GPS signals received by said positioning assistant that is a GPS receiver.

93. The self-contained/interruption-free positioning method, as recited in claim 91, wherein the step (b) further comprises a step of deducing raw positioning data through said wireless communication device.

94. The self-contained/interruption-free positioning method, as recited in claim 91, 92 or 93, wherein the step (c) comprises the steps of:

(c.1) sensing an earth's magnetic field to measure a heading angle of said user by a magnetic sensor,

(c.2) measuring a relative velocity of said user relative to a ground by a velocity producer to produce a measured velocity, and

(c.3) measuring altitude measurement of said user to form a mean sea level height of said user in digital manner;

(c.4) blending said digital angular increments and velocity increments signals, said heading angle, said relative velocity of said user relative to said ground, said mean sea level height and said GPS positioning data to produce optimal positioning data.

95. The self-contained/interruption-free positioning method, as recited in claim 94, wherein the step (c.4) further comprises the steps of:

c.4.1 computing inertial positioning measurements using said digital angular increments and velocity increments signals;

c.4.2 computing said heading angle using said earth's magnetic field measurements,

c.4.3 creating relative position error measurements in said velocity producer processing module using said relative velocity of said user relative to said ground for a Kalman filter,

c.4.4 converting said altitude measurements to said mean sea level height of said user in digital manner; and

c.4.5 estimating errors of inertial positioning measurements by means of performing Kalman filtering computation to calibrate said inertial positioning measurements.

96. The self-contained/interruption-free positioning method, as recited in claim 95, wherein the step (c.4.1) further comprises the steps of:

c.4.1.1 integrating said angular increments into attitude data, referred to as attitude integration processing;

c.4.1.2 transforming said measured velocity increments into a suitable navigation coordinate frame by use of said attitude data, wherein said transferred velocity

increments are integrated into velocity data, denoted as velocity integration processing, and

c.4.1.3 integrating said navigation frame velocity data into position data, denoted as position integration processing.

97. The self-contained/interruption-free positioning method, as recited in claim 96, wherein the step (c.4.5) further comprises the steps of:

c.4.5.1 performing motion tests to determine whether said user stops to initiate a zero-velocity update;

c.4.5.2 determining whether GPS data available using a GPS state status indicator from said GPS receiver;

c.4.5.3 formulating measurement equations and time varying matrix for said Kalman filter; and

c.4.5.4 computing estimates of said error states using said Kalman filter.

98. The self-contained/interruption-free positioning method, as recited in claim 94, wherein the step (c.2) further comprises the steps of:

(c.2.1) transforming said measured velocity expressed in a body frame into a navigation frame;

(c.2.2) comparing said measured velocity with an IMU velocity to form a velocity difference; and

(c.2.3) integrating said velocity difference during a predetermined interval.

99. The self-contained/interruption-free positioning method, as recited in claim 97, wherein the step (c.2) further comprises the steps of:

(c.2.1) transforming said measured velocity expressed in a body frame into a navigation frame;

(c.2.2) comparing said measured velocity with an IMU velocity to form a velocity difference; and

(c.2.3) integrating said velocity difference during a predetermined interval.

100. The self-contained/interruption-free positioning method, as recited in claim 94, wherein the step (b) further comprises an additional step of diffentially deducing said GPS positioning data through a data link.

101. The self-contained/interruption-free positioning method, as recited in claim 99, wherein the step (b) further comprises an additional step of diffentially deducing said GPS positioning data through a data link.

102. The self-contained/interruption-free positioning method, as recited in claim 92, wherein said additional step of said step (b) further comprises a step (b.1) of fixing integer ambiguities based on testing an occurrence of new satellites or cycle slips using said GPS rover raw measurements from said GPS processor, GPS reference raw measurements, position, and velocity from said data link, and said inertial navigation solution from said INS processor and send said integer ambiguities to a Kalman filter.

103. The self-contained/interruption-free positioning method, as recited in claim 102, wherein step (b.1) further comprises the steps of:

(b.1.1) injecting said GPS rover raw measurements from said GPS processor, GPS reference raw measurements, position, and velocity from said data link,

and said inertial navigation solution from said INS processor into a new satellites/cycle slips detection module to test the occurrence of new satellites or cycle slips;

(b.1.2) initiating an on-the-fly ambiguity resolution module as said new satellites/cycle slips detection module is on when the new satellites or cycle slips occur;

(b.1.3) fixing integer ambiguities to estimate a more accurate user navigation solution, and

(b.1.4) sending said selected integer ambiguities from said on-the-fly ambiguity resolution module to said Kalman filter

104. The self-contained/interruption-free positioning method, as recited in claim 103, wherein the step (b.1.2) further comprises the steps of:

(b.1.2.1) setting up a search window which comprises a plurality of time (N) epochs;

(b.1.2.2) searching an integer ambiguity set at said first time epoch of said search window by using an ISAA, that is intermediate ambiguity search strategy, wherein said integer ambiguity set becomes a member of said estimator bank while there is no member in said estimator bank before said first time epoch, wherein based on said integer ambiguity set and phase measurements, said rover position is estimated in said estimator bank, and then a corresponding weight is calculated in said weight bank, as a result, an optimal rover position for said time epoch is equal to said rover position multiplied by said corresponding weight, and based on said optimal rover position and said Doppler shifts, said rover velocity is estimated;

(b.1.2.3) searching said integer ambiguity set at said second time epoch of said search window by using said IASS;

(b.1.2.4) following the step (b.1.2.3) for said other time epochs of said search window, wherein at said last time epoch N of said search window, after said search of said IASS, said estimator bank and said corresponding weight bank are completely established;

(b.1.2.5) inputting continuously said phase measurements into each of said Kalman filters of said estimator bank at the $(N+1)^{th}$ time epochs, wherein based on each of said integer ambiguity sets and said phase measurements, an individual rover position is estimated in said estimator bank and each corresponding weight is calculated accumulatively in said weight bank to an associated weight, therefore said optimal rover position is equal to a sum of said individual rover position multiplied by said associated weight, and further based on said optimal rover position and Doppler shifts, said rover velocity is estimated;

(b.1.2.6) following the step (b.1.2.5) after said $(N+1)^{th}$ time epoch until a criterion is met, wherein after said criterion is met, said estimator bank and said weight bank stop functioning, and during a confirmation period, that is from said first time epoch of said search window to said last time epoch when said estimator bank and said weight bank stop functioning, said estimator bank and said weight bank continuously identify a correct integer ambiguity set and estimate said rover position in real-time, wherein said weight corresponding to said correct integer ambiguity is approaching to one while said other integer ambiguity sets are converging to zero; and

(b.1.2.7) estimating said rover position and velocity by using said least-squares estimated method after fixing integer ambiguities; as new satellites or cycle slips occur, the process (i.e. steps (b.1.2.1) – (b.1.2.7)) will be initiated.

105. The self-contained/interruption-free positioning method, as recited in claim 104, in the step (b.1.2.3), wherein when said integer ambiguity set is same as one of said previous time epoch, said number of said Kalman filter remains, wherein based on said integer ambiguity set and said phase measurements, said rover position is estimated in said estimator bank and said corresponding weight is accumulatively calculated in said

weight bank, as a result, said optimal rover position is equal to said rover position multiplied by said associated weight and based on said optimal rover position and said Doppler shifts, said rover velocity is estimated.

106. The self-contained/interruption-free positioning method, as recited in claim 104, in the step (b.1.2.3), wherein when said integer ambiguity set is different from one of said previous time epoch, said current integer ambiguity set becomes a new member of said estimator bank, that is a number of said Kalman filters increases by one, wherein based on each of said integer ambiguity sets and said same phase measurements, an individual rover position is estimated in said estimator bank and a calculation of each corresponding weight is recalculated from scratch in said weight bank, and therefore said optimal rover position is equal to a sum of said individual rover position multiplied by said associated weight, wherein based on said optimal rover position and said Doppler shifts, said rover velocity is estimated.

107. The self-contained/interruption-free positioning method, as recited in of claim 104, 105 or 106, wherein said IASS comprises the steps of:

resolving primary double difference wide lane ambiguities in a primary double difference wide lane ambiguity resolution module, wherein a priori information of said rover position obtained from ionosphere-free pseudorange measurements and an approximated double difference wide lane ambiguities are combined with said primary double difference wide lane phase measurements to estimate said rover position and said primary double difference wide lane ambiguities;

establishing an ambiguity search domain based on said estimated primary double difference wide lane ambiguities and said corresponding cofactor matrix;

searching for an ambiguity set by using a "simplified" least-squares search estimator;

computing said rover position based on said fixed primary double difference wide lane ambiguities in a position calculation module;

fixing secondary double difference wide lane ambiguities by applying said primary wide-lane-ambiguity-fixed rover position solution into said secondary double difference wide lane phase measurements;

calculating approximated double difference narrow lane ambiguities and then using said extrawidelaning technique module to resolve double difference narrow lane ambiguities; and

calculating L1 and L2 ambiguities in a L1 and L2 ambiguity resolution module from said combination of said double difference wide lane ambiguities and said double difference narrow lane ambiguities.